

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS—MILTON WHITNEY, Chief.

SOIL SURVEY OF THE CARLTON AREA, MINNESOTA-WISCONSIN.

BY

W. J. GEIB AND GROVE B. JONES.

[Advance Sheets—Field Operations of the Bureau of Soils, 1905.]



WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1906.

[PUBLIC RESOLUTION—No. 9.]

JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled. That public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

That there shall be printed ten thousand five hundred copies of the report on field operations of the Division of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided*, That in addition to the number of copies above provided for there shall be printed, as soon as the manuscript can be prepared, with the necessary maps and illustrations to accompany it, a report on each area surveyed, in the form of advance sheets, bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the Congressional district or districts in which the survey is made, and one thousand copies for the use of the Department of Agriculture.

Approved, March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils.]

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., May 24, 1906

SIR: In response to a request from the Commercial Club of Duluth, which was transmitted to the Department of Agriculture by the Hon. J. Adam Bede, a soil survey of the Carlton area, Minnesota, was directed for the field season of 1905. In making the request for this area, the reason was particularly pointed out by Mr. Bede, who says:

I have the honor to request earnestly that you give the benefit of the valuable soil surveys of your Department to the section included in the counties of St. Louis, Aitkin, Pine, and Carlton, Minn. While there is a variety of soils in this section, generally it is known as "cut-over pine lands." The section is rapidly settling up, and I firmly believe there is not a locality in the country where a soil survey would do more good.

I have the honor to transmit herewith the map and report on the Carlton area, Minnesota, and recommend the publication of this report as advance sheets of the Field Operations of the Bureau of Soils for 1905, as authorized by law.

Respectfully,

MILTON WHITNEY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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SOIL SURVEY OF THE CARLTON AREA, MINNESOTA-WISCONSIN.

By W. J. GEIB and GROVE B. JONES.

LOCATION AND BOUNDARIES OF THE AREA.

The area surveyed lies in the northeastern part of Minnesota, at the head of Lake Superior, and includes twelve townships, numbers 47, 48, and 49, ranges 15, 16, 17, and 18. Nine of these are within Carlton County, Minn., while the St. Louis River equally divides the territory of the remaining three between St. Louis County, Minn., and Douglas County, Wis. The west boundary line of the Superior area, which was surveyed during the season of 1904, forms the east boundary line of the Carlton area.

Carlton, the county seat of Carlton County, lies at the junction of the Great Northern and Northern Pacific railroads, and has a population of about 600. Cloquet, with a population of 6,000 and located 6 miles north of Carlton, is an important lumber center and

has the reputation of having the largest annual lumber output of any town in the United States. Scanlon, Thomson, Mahtowa, New Duluth, Fond du Lac, and Smithville are towns of lesser importance. A small portion of West Duluth is included within the survey, and Barnum, a town of about 500 population, lies just outside of the southwest corner of the area.

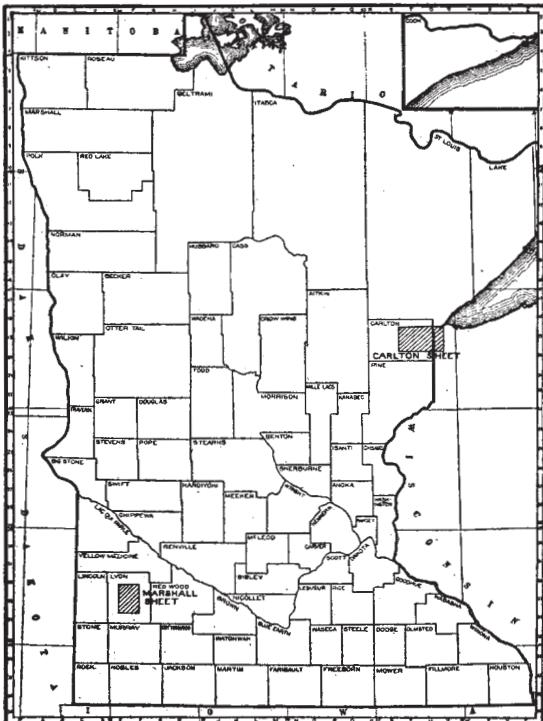


FIG. 1.—Sketch map showing location of the Carlton area, Minnesota-Wisconsin.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

As early as 1650 the region about the head of Lake Superior was visited by fur traders and explorers, and about 1659 a trading post was established at Fond du Lac, a few miles from the mouth of the St. Louis River, which was at that time known as the Fond du Lac River. This waterway afforded the only means by which the interior could be reached, and down the St. Louis came a good portion of the furs shipped from the head of the lake in early days. Game was plentiful in this region, and for a century and a half Fond du Lac was one of the leading posts of Lake Superior.

From 1659 to 1854, a period of nearly two hundred years, the area surveyed was visited by the fur trader, the missionary, the pioneer, and the officers of the Government, and a few settlements were made; but through all this period it is not known that any attempt was made to cultivate the soil to any extent, and no towns were built of any more importance than a trading post or mission station.

In 1847 a treaty was made at Fond du Lac between the Chippewa Indians and the United States Government, by which the greater part of northern Minnesota was ceded to the United States and opened for further exploration and settlement. The Indians were usually kindly disposed and gave the early settlers but little trouble.

Minnesota Territory was organized in 1849, and in the same year the Territorial legislature created Itasca County. This embraced the vast region lying between the Mississippi River and Wisconsin Territory and extended from $46^{\circ} 30'$ north latitude to the Canadian boundary line. From this domain the counties of St. Louis, Cook, Lake, a part of Beltrami, and Aitkin were created, and in 1857 Carlton County was created from a portion of St. Louis, though it was not reduced to its present limits until 1870.

By 1854 Fond du Lac, Minn., and Superior, Wis., had become ports of considerable importance, and up to that time their only means of communication with the outside world was by boat over the lakes to eastern points or through the unbroken forest to points on the St. Croix and Mississippi rivers. Through the efforts of the district representative Congress made an appropriation for the building of the military road between Fond du lac and Superior and St. Paul. This road was completed in 1856, and its establishment greatly facilitated travel, made possible greater regularity in the mail service, and stimulated the desire for developing the resources of northeastern Minnesota.

The agricultural history of the area may be said to have begun with the first settlement made on the old military road at Twin Lakes, in Carlton County. Several small farms were cleared and put under cultivation during that year, and since that time the development of

the community has been comparatively rapid, though the town of Twin Lakes no longer exists.

The first railroad built in northeastern Minnesota and entering the area was the Mississippi and Lake Superior, now known as the Duluth and St. Paul Short Line and operated by the Northern Pacific Railroad. This line was completed in 1870 and marked a new epoch in the development of the lumber industry. Prior to this date comparatively little interest had been manifested in the vast forests of pine which existed, but after the completion of this railroad large lumber companies saw the opportunity to reap a rich harvest from them. Numerous sawmills were put into operation, and the towns of Barnum, Mahtowa, Carlton, Thomson, and Cloquet were soon important lumbering centers.

In the early days of the lumbering industry only the straightest and best trees were cut, but as the timber became scarcer and the demands greater every tree which could possibly be utilized was taken. At present the pine within the area is practically exhausted. The small amount of timber remaining consists chiefly of birch and maple.

Cloquet and Scanlon are now the only towns within the area at which sawmills are operated. The timber for these mills is floated down the St. Louis River or brought in by rail from points 10 to 75 miles distant.

The land stripped of timber was allowed to remain as the lumbermen had left it. The old trunks of trees, brush, and the grass which grew up each season and died down in the fall afforded a good starting place for the forest fires, which did much damage to property and often destroyed many lives.

The pine lands were at first considered to be of little value for agricultural purposes, and consequently the development along this line has been slow. As the timber became scarcer, however, and as many of those who had worked in the woods did not care to follow the lumbering industry to new timber lands, the only alternative for them was to make for themselves a home in the once famous pine country. Other settlers came in slowly, and it was soon found that potatoes, oats, hay, and vegetables could be grown successfully on any of the soils.

The lumber companies which had bought the land for the timber were willing to sell very cheaply, and it was not long until the greater part of the "cut-over land" was in the hands of large real-estate firms, who proceeded to bring the attention of the land-buying public to northeast Minnesota.

In 1870 the population of the region included within the area surveyed was about 400, and by 1900 it had increased to nearly 10,000. Early immigration came largely from the Eastern States, though for the last fifteen years Germany, Norway, and Sweden have contributed largely to the growing population.

CLIMATE.

As the Weather Bureau has no stations within the area surveyed, no records are available which deal directly with the climatic conditions as they exist. The data given below are from the Duluth station, which is about 3 miles distant from the northeast corner of the area, and from the station at Sandy Lake Dam, which is 60 miles west of Duluth. The records from the former will be found fairly accurate for the eastern part of the area, which is more subject to the influence of the lake, while for the conditions of the west half of the area the latter should be consulted.

A temperature of 99° F. has been recorded at the Duluth station, and the thermometer has gone as low as -41°, so that the extreme range of temperature is about 140° F. During the last twenty-seven years the average date of the last killing frost in the spring has been May 2, and the first in the fall September 30. The latest killing frost known in this region occurred June 8, 1885, and the earliest in the fall September 15, 1874. The average annual snowfall is 40 inches.

During eight months of the year the prevailing winds are from the northeast, but for the remaining four, including the growing season, they are from the west and southwest. While the growing season is comparatively short and usually late in opening, vegetation makes a very rapid growth when the warm weather begins. The rains are equally distributed throughout the growing season and crops do not suffer from drought. The greatest precipitation occurs in June in the form of thundershowers.

Normal monthly and annual temperature and precipitation.

Month.	Duluth.		Sandy Lake Dam.		Month.	Duluth.		Sandy Lake Dam.	
	Temper- ature.	Precip- itation.	Temper- ature.	Precip- itation.		Temper- ature.	Precip- itation.	Temper- ature.	Precip- itation.
January.....	10.4	1.07	6.1	0.85	August.....	64.7	3.34	64.5	3.81
February....	14.7	1.15	6.2	.75	September..	56.2	3.86	55.7	2.29
March.....	24.0	1.66	1.51	October....	44.9	2.59	44.3	2.53
April.....	37.9	2.42	40.5	2.20	November..	29.4	1.61	26.1	1.01
May.....	48.0	3.68	53.4	3.07	December...	17.8	1.36	11.7	.87
June.....	57.8	4.59	62.6	3.22	Year..	39.3	31.05	25.97
July.....	65.9	3.72	67.0	3.86					

PHYSIOGRAPHY AND GEOLOGY.

The topography of the Carlton area is characteristic of a glacial region and varies from low, almost level plains to rolling and hilly uplands. There are three distinct physiographic divisions, consisting of the glaciated uplands, the old outlet to Lake Superior through which the water of the lake was formerly carried to the southwest, and the

Nemadji Plains, consisting of lacustrine deposits laid down in a former extension of Lake Superior.

The surface of the glaciated uplands varies from gently rolling to rolling and hilly. This irregularity is due to the uneven distribution of the glacial and morainic material on the retreat of the ice sheet, to erosive action of glacial streams through which large quantities of material were carried into glacial lakes, and to the more recent erosion of the streams which now pass through the area. The uplands are bounded on the east by a range of hills which outlines the basin of Lake Superior in the vicinity of Duluth, terminating within the area at Short Line Park. This range has an elevation of 1,300 feet, while Lake Superior is 602 feet above sea level. The entire change is effected, generally, within an interval of less than a mile. At West Duluth there is a narrow strip of level land between the base of the hills and the shore of the lake, which gradually increases in width toward the southwest. The steeper slopes of the range consist of a series of rugged rock outcrops, while on the more gentle descents the surface is thickly strewn with stones and boulders. Extending westward from the range of hills the elevation rises slightly, forming the uplands already described, which at a point directly north of Cloquet, near the north line of Carlton County, reach an elevation of 1,450 feet. Another range of hills begins at a point 3 miles to the southwest of Carlton, on the south side of Otter Creek, and extends in a southwesterly direction for 5 miles. It varies in width from $1\frac{1}{2}$ to 3 miles and is composed largely of morainic material.

The greater part of the course of the St. Louis River within the area is bounded on both sides by high walls composed of the morainic and drift materials of the region. These walls are distant from the river proper from one-half mile to 2 miles, are undulating or rounded, and cut by numerous drainage courses. From Cloquet down to near Fond du Lac the river flows on the bed rock, and from Cloquet to Thomson the floor of the valley is thickly covered with boulders. There is a series of rock outcrops on both sides of the river, and at the railroad bridge which crosses the river near Thomson the cliffs reach an elevation of 50 feet. At Thomson the surface materials change to lacustrine, thus assuming the character seen in the Nemadji Valley. The immediate valley eastward from Thomson is therefore of more recent excavation than that part eroded through the morainic drift.

Otter Creek, which joins the St. Louis River at Thomson, flows in an old channel between drift walls, which are quite marked and separated from each other by a distance of from 1 to 2 miles. The old channel is distinctly traceable for some distance to the southwest, approximately in the direction of the Duluth and St. Paul Short Line Railroad, but somewhat to the south of the track. The valley continues in a southwesterly direction and at Atkinson unites with

the valley of the Moosehorn River, which passes out of the area about 1 mile north of the southwest corner of the tract surveyed. This channel is probably the oldest and highest of the westward outlets of Lake Superior and was formed through the terminal moraine which bounded the Superior ice lobe in glacial times. The surface of this old channel is nearly level, but slopes gently toward the course of the stream.

The Nemadji Valley occupies the southeastern part of the area extending north to the St. Louis River and west to an imaginary line drawn from Thomson through Wrenshall to a point 6 miles east of Barnum, which is situated one-half mile west of the southwest corner of the area. This division is a lacustrine plain underlain by stratified clay and fine sand and is the most westward extension of the great valley of Lake Superior. Its westward boundary is distinctly marked by the abrupt change which takes place in the contours in passing to the drift area proper. The surface is nearly flat, but slopes gently toward the Nemadji River, which runs into Lake Superior. The streams have excavated canyonlike valleys in this deposit to a depth of from 40 to 100 feet, but so far as is known the bed rock has in no place been reached by the erosion.

The underlying rocks of the Carlton area have but little direct influence upon the soils. The formations belong to the Archean and Cambrian, and consist chiefly of slates, sandstone, and gabbro. While outcropping here and there in the area, these rocks are generally deeply buried beneath the glacial drift or glacial drift reworked and redeposited in ancient lakes. The largest outcrop occurs along the steep slope of the range of hills southwest of West Duluth.

The glacial drift, which everywhere covers the area to a depth of from 50 to 100 feet, was modified in part after the first deposition, and as a result we have considerable variety in the soils. The rolling glaciated uplands give rise to the Miami series, the types of which show marked textural differences, owing to the assorting action of water. In the northeast part of the area the predominance of fine material mingled with a relatively larger proportion of stone gives rise to a light loam termed Miami stony loam. In the western and northwestern parts the material consists chiefly of medium and fine sand with varying proportions of organic matter, and the soils derived therefrom are Miami sandy loam and Miami fine sand. In the southwestern part of the area there is a large quantity of fine particles in the material, giving rise to a heavier loam type. Where this is underlaid near the surface by clay or clay loam it has been mapped Barnum loam, and where the subsoil is of a sandy nature grading into clay loam at a greater depth the type has been called the Barnum stony loam. This underlying clay is of a reddish color. In other parts of the rolling uplands a slight red color may often be seen. This colora-

tion is due to the presence of iron, which was probably carried down from the iron-bearing rocks to the north.

The materials comprising the Nemadji Plain is a deposit laid down in Lake Superior when that body of water stood 500 feet above its present level. The sediment was derived from the then recently deposited sheet of drift which covered the country roundabout. The till which underlies the Nemadji Valley is red and was derived largely from the rocks of the Keweenawan formation toward the east, but the sediment that lies on this, forming the laminated clay to a depth of from 4 to 50 feet, came more generally from the west. The red color, which is prevalent here and which appears to a limited extent in most of the soils of the area, is due to the presence of iron. The soils which have been derived from this deposit belong to the Superior series, of which the Superior clay, consisting of the finest material brought down by the glacial streams, occupies the greater part of the valley. The Superior silt loam, which occurs along the border of the Nemadji Plain, was derived from material in which the particles were larger and heavier than the clay particles and which on account of their greater weight were deposited near the shore of the lake.

SOILS.

Twelve soil types, not including rock outcrop, were recognized in the area surveyed. The following table shows the acreage and relative extent of each type:

Areas of different soils.

Soils.	Acres.	Percent.	Soils.	Acres.	Percent.
Superior clay.....	75,200	28.8	Meadow.....	5,248	1.9
Miami sandy loam.....	54,784	20.7	Miami gravelly sandy loam..	5,184	1.9
Miami stony loam.....	50,560	19.1	Rock outcrop.....	3,840	1.4
Miami sand.....	17,408	6.6	Barnum loam.....	2,496	.9
Muck.....	17,408	6.6	Miami fine sand.....	1,920	.7
Superior silt loam.....	16,192	6.1	Total.....	264,384	
Barnum stony loam.....	8,704	3.3			
Rough stony land.....	5,440	2.0			

MIAMI STONY LOAM.

The Miami stony loam is the most important type of the area and the one upon which the greatest agricultural development has taken place. The soil consists of a brown or light-brown loam, slightly sandy, extending to a depth of from 10 to 12 inches, and usually underlain by a heavy sandy loam or loam of lighter color to a depth of 36 inches. Both soil and subsoil may contain a small percentage of gravel, and in local areas a gravel bed is encountered at from 2 to 3 feet. Where the larger amounts of gravel occur the sand particles

are larger. The surface is strewn with rounded and angular glacial stones and bowlders. The quantity of these present on the surface and mixed with the soil varies from 15 to 40 per cent, while the fragments range in size from 2 inches to 2 feet in diameter. Where the stones are most numerous they interfere considerably with cultivation and their removal is necessary before improved farm machinery can be successfully used.

The largest area of the Miami stony loam lies on the north side of the St. Louis River, and comprises about 65 square miles, extending from a point opposite Cloquet to the range of hills overlooking the basin of Lake Superior and reaching north to the boundary of the sheet. The continuity of this area is broken only by a few small Muck areas. The stones and bowlders are more numerous here than on the remainder of the type, and are often plentiful enough to interfere with cultivation, especially in the northeastern part. Another area of considerable size lies to the south of Carlton, and here the texture of soil is coarser. The stones are not so prevalent in this section and cause but little inconvenience in the various farm operations. Other small irregular occurrences of this type are found in various parts of the area.

In topography the surface of the type varies from rolling to hilly. The roughest portion lies in the northeastern part of the area, where the range of hills which extends to the northeast from Short Line Park marks the boundary between the upland and the valley of Lake Superior. South and east from Atkinson is a small area which is nearly level. Here the soil is a brown loam to a depth of 22 inches, underlain by a heavy sandy loam. Other low-lying areas of small extent occur throughout the type, and in these the soil is usually heavier than on the higher elevations.

On account of its uneven topography and the slightly sandy nature of its subsoil, the natural drainage over the great proportion of the type is good. The low-lying areas are often very wet during the spring of the year, and in some of these a condition approaching swappiness now exists. By cutting a few open drains, which would require but comparatively little labor, these areas could be readily reclaimed.

The soil of the Miami stony loam is derived from the glacial and morainic drift which covers the greater part of this region. The clay underlying this type at various places resembles the surface soil of the Superior clay, though of somewhat lighter texture, and was probably originally derived from the same source.

The estimated average yields from this soil are 35 bushels of oats, 30 bushels of barley, $1\frac{1}{2}$ tons of hay, and 175 bushels of potatoes per acre. Wheat yields from 20 to 30 bushels per acre, though little of this grain is grown. Root crops and vegetables also do well.

The Miami stony loam is adapted to general farming, dairying, and stock raising, and should be devoted to these industries.

The following table shows the results of mechanical analyses of the fine earth of this type:

Mechanical analyses of Miami stony loam.

Number.	Description.	Fine	Coarse	Me-	Fine	Very	Silt.	Clay.
		gravel.	sand.	di-	sand.	fine	Per ct.	Per ct.
13562.....	Soil.....	0.2	1.8	3.4	12.8	17.7	52.0	11.5
13563.....	Subsoil.....	.5	2.5	4.2	19.5	17.9	44.1	10.9

BARNUM STONY LOAM.

The Barnum stony loam to a depth of 12 inches consists of a light-brown loam, underlain by a heavy sandy loam grading into red clay at from 22 to 36 inches. On the surface and mixed with the soil are stones and boulders, which often occur in sufficient quantity to interfere with cultivation.

The type is confined to the southwest corner of the area surveyed and is of glacial origin. Its topography is rolling and hilly, being similar in this respect to the Miami stony loam, and the natural drainage for the most part is good. Where the surface is not too rough and broken and the stones not too numerous, the type is suited to the general crops of the region. Fairly good crops of oats, hay, and wheat can be grown.

The following table gives the results of mechanical analyses of the fine earth of this type:

Mechanical analyses of Barnum stony loam.

Number.	Description.	Fine	Coarse	Me-	Fine	Very	Silt.	Clay.
		gravel.	sand.	di-	sand.	fine	Per ct.	Per ct.
13564.....	Soil.....	0.1	3.3	5.1	14.1	11.7	47.2	18.1
13565.....	Subsoil.....	.4	3.1	8.5	23.2	12.8	33.0	18.9

SUPERIOR CLAY.

The soil of the Superior clay to a depth of 6 inches is a heavy tenacious red clay. The accumulation of a small amount of organic matter at the surface has imparted to the first 2 or 3 inches a brownish color, and in a few local areas there was found to be a light-colored silty material covering the soil to a depth of from 1 to 3 inches. The subsoil consists of a heavy, stiff, tenacious red clay. A few lime concretions may occur on the surface and in the soil and subsoil. When wet the soil becomes very sticky, adhering tenaciously to the wheels of vehicles and greatly impeding travel.

The Superior clay is a very uniform type, and the boundary line between it and the other types can be readily traced by the increase in the elevation and the marked change in the character of the soil. It is found in the southeastern part of the area and there occupies an unbroken stretch of over 100 square miles. An imaginary line drawn from West Duluth through Fond du Lac and Barker to a point $7\frac{1}{2}$ miles east of Barnum, which lies just outside the western limits of the survey, separates the main body of the Superior clay from the other types mapped. Directly east of Thomson there is a small, isolated area of clay, and at Wrenshall is another occurrence from which an excellent quality of brick is being manufactured. To the north and east of Wrenshall, and extending along the St. Louis River for several miles, the clay is overlain by a covering of fine sandy and silty loam, which gives rise to the Superior silt loam.

The surface of the Superior clay is level or slightly rolling. The Nemadji River, with the many small streams tributary to it, drains the larger part of the type. These streams have cut deep, canyon-like valleys through this deposit, and in a few instances the eroded channels are so close together and the slopes are so steep that the land is unfit for agricultural purposes. On account of the heavy, compact character of the clay artificial drainage will be necessary over a large proportion of the type before the soil can be cultivated with the greatest success.

The soil is a lacustrine deposit laid down in Lake Superior when that body of water stood some 500 feet above its present level. The sediment, which was derived largely from the sheet of glacial drift covering this region, extends to a depth of from 4 to 50 feet. The till underlying this is supposed to have been derived from the rocks of the Keweenawan toward the east.

Notwithstanding the Superior clay is the most extensive type, it is one of the least developed soils of the area. Only a few fields have been cleared and put under cultivation, but from these an idea of the agricultural value of the soil was obtained. The wild grasses, clover, and timothy do very well, and if the bushes were removed a good crop of wild hay could be cut each year. Hay yields from 1 to 2 tons per acre, while 40 bushels of oats is considered an average crop. Potatoes produce at the rate of 100 bushels per acre. The yields of the various crops are usually larger after the soil has been worked for a few years, for by continued cultivation and the mixing of more organic matter with the soil it loses to some extent its heavy, tenacious character. Excellent pasture is afforded throughout the summer and the type should be used for grazing and the production of hay.

The average texture of both soil and subsoil is shown in the following table of mechanical analyses:

Mechanical analyses of Superior clay.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
12925, 13570.....	Soil.....	0.4	1.5	1.6	8.3	6.4	21.8	59.9
12926, 13571.....	Subsoil....	.1	.9	1.3	10.6	8.7	23.5	54.5

SUPERIOR SILT LOAM.

The soil of the Superior silt loam to a depth of from 6 to 10 inches consists of a light-colored very fine sandy or silty loam, underlain by a very fine sandy loam or silty loam, having in some places the properties of a clay and grading into a stiff red clay at varying depths. The underlying clay, which is of the same origin as the Superior clay, may be encountered at from 2 to 3 feet or it may lie many feet below the surface. The cuts along the Great Northern Railroad to the north and east of Wrenshall show this very fine sandy and silty material, which presents a stratified appearance, to extend to a depth of from 20 to 30 feet.

The largest area of the Superior silt loam lies between Wrenshall and the State line, extending north from Barker to the St. Louis River, and thence in a northeasterly direction to a point $2\frac{1}{4}$ miles north of Fond du Lac. A few irregular areas extend southwest from Wrenshall to the southern edge of the map.

Over the greater proportion of the type the surface is rough and broken, being deeply eroded by stream action. The slopes, which are now covered with a dense growth of underbrush, are too steep to be cultivated. The small areas to the southwest of Wrenshall are nearly level and when drained should be capable of producing fair crops.

The Superior silt loam is closely associated with the Superior clay. It is a glacial soil reworked by the action of water. The underlying clay was derived from the same source as the Superior clay, and the very fine sandy and silty material was probably carried down by glacial streams and deposited at a later date.

None of the type is now under cultivation, and on account of its uneven topography the greater part is of little value for agricultural purposes.

The following table gives the average results of mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Superior silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>				
13572, 13574.....	Soil.....	0.3	0.9	0.6	1.8	11.3	67.9	16.3
13573, 13575.....	Subsoil....	.4	.8	.5	2.0	7.1	65.8	22.6

MIAMI SANDY LOAM.

The soil of the Miami sandy loam consists of a brown or light-brown sandy loam of medium texture extending to a depth of from 8 to 14 inches. There is usually mixed with the soil a small amount of gravel, although there are considerable areas where the soil is entirely free from coarse material. The subsoil consists of a medium or coarse light sandy loam containing varying amounts of gravel and grading into beds of gravel or sand at from 2 to 3 feet. The pebbles in this gravel are much worn by the action of water and seldom exceed one-half inch in diameter.

About 86 square miles of the Miami sandy loam were mapped, the areas being confined almost entirely to the west half of the survey. The type occupies three-fourths of that part of the Fond du Lac Reservation lying within the area and extends south to the Moosehorn River and the Duluth and St. Paul Short Line Railroad. It is here found in one continuous body, broken only by small areas of Muck and Miami stony loam. From a point about 1 mile southeast of Atkinson an irregular area extends to the southern boundary of the survey, and over the greater part of this area the soil is of a coarser texture than the remainder of the type. Small areas also are found south of Wrenshall, along the border of the Superior clay.

The surface of the Miami sandy loam for the most part is undulating or rolling. A marked exception to this is found, however, in a range of hills which begins $1\frac{1}{2}$ miles northwest of Atkinson and extends in a northeasterly direction for about $2\frac{1}{2}$ miles. These hills vary in height from 20 to 40 feet and represent morainic material. The soil of this ridge is very light, contains a high percentage of gravel, and is underlain by a gravel bed at from 2 to 3 feet.

The soil of the Miami sandy loam is derived from glacial material, and that portion within the Fond du Lac Reservation and extending south probably represents a glacial flood plain. The small areas occurring along the border of the Superior clay were undoubtedly somewhat modified by the action of Lake Superior.

The sandy nature of the soil insures good drainage, and in seasons of insufficient rainfall crops are apt to suffer more from drought than on the heavier types of soil.

The original timber growth consisted chiefly of white, Norway, and jack pine. Within the Indian reservation there is still a small quantity of standing timber, though over the greatest part of the type there is only an inferior growth of birch, hazel, and poplar.

Only a small percentage of the Miami sandy loam is under cultivation. Potatoes yield 150 bushels, oats 30 bushels, and, in seasons of sufficient rainfall, hay 1½ tons to the acre. The soil is well adapted to truck farming and should be devoted to that industry.

The following table gives the average results of mechanical analyses of the soil and subsoil of the Miami sandy loam:

Mechanical analyses of Miami sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
13540, 13542, 13544, 13546.....	Soil.....	3.4	18.6	18.2	19.3	8.1	22.3	10.0
13541, 13543, 13545, 13547.....	Subsoil....	4.1	16.8	24.2	23.8	6.9	12.4	6.6

MIAMI SAND.

The Miami sand consists of a medium sand extending to a depth of from 6 to 10 inches. An accumulation of a small amount of organic matter in the first 3 or 4 inches imparts to the soil a brownish color, and there is present on the surface and mixed with the soil a small amount of fine gravel. The subsoil consists of a medium or coarse sand, sometimes grading into coarse sand containing fine gravel. A gravel bed may be encountered at from 2 to 3 feet, and in this the pebbles are usually less than one-fourth inch in diameter and much worn by the action of the water.

Beginning at a point 2½ miles southwest of Carlton, on the south side of Otter Creek, and extending southward to Sand Lake, is a large area of this type varying in width from one-half mile to 3 miles. In this area the surface is rolling and broken, consisting of a series of hills and ridges varying in height from 20 to 50 feet. The slopes are often very steep and, with the exception of a few farms about Sand Lake, where the surface is only slightly rolling, this soil is not used for agricultural purposes. The original timber growth consisted chiefly of Norway and jack pine, and after this was removed the land was allowed to remain idle. The fires which have swept over this region partially consumed the old logs and litter left by the lumbermen and also destroyed the young pine which had sprung up. There is now only a scanty growth of poplar, birch, hazel, and huckleberry bushes, with an occasional cluster of young pine.

Another area of Miami sand is located near the center of that part of the Fond du Lac Reservation which lies within the area surveyed. Here the surface is but slightly rolling and there is a less amount of gravel present in the soil and subsoil than in the area just above. There are a few small patches throughout this part of the type in which the soil is of a coarse texture, and in these places a gravel bed is usually encountered at from 2 to 3 feet.

The Miami sand is a glacial soil, representing glacial flood plains and the accumulation of morainic material. On account of the loose, open character of the soil, together with its uneven topography, the natural drainage is good. In seasons of deficient rainfall crops suffer from drought, though this soil is more retentive of moisture than its open character would indicate.

About Sand Lake, where the type is under cultivation, fair crop yields are secured. Potatoes of excellent quality are grown and the yield ranges from 100 to 200 bushels per acre. A yield per acre of 30 bushels of oats is considered about the average, while in wet seasons hay yields from 1 to 1½ tons. Strawberries do well, and the portion of the type which is not hilly is well adapted to the growing of small fruit and truck farming.

The average results of mechanical analyses of the fine earth of the soil and subsoil appear in the following table:

Mechanical analyses of Miami sand.

Number.	Description.	Fine gravel.	Coarse sand.	Me- di- um sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per. ct.
13552, 13556.....	Soil.....	0.9	11.7	19.1	56.3	7.0	2.0	2.8
13553, 13557.....	Subsoil....	3.7	23.5	20.4	44.7	5.4	1.7	2.4

MIAMI GRAVELLY SANDY LOAM.

The soil of the Miami gravelly sandy loam consists of a gravelly sandy loam from 10 to 14 inches deep. The interstitial material varies from a medium to fine sandy loam or loam. The subsoil to a depth of 36 inches is a medium or coarse light sandy loam mixed with gravel and often grading into a gravel bed at from 2 to 3 feet. The higher elevations contain a high percentage of gravel and are usually underlain by a gravel bed, while in the depressions the soil is practically free from gravel.

About 9 square miles of this type were mapped. The largest area, which varies in width from one-half mile to 1½ miles, extends from Cloquet to a point 3 miles west of Carlton. Another area of much smaller extent lies to the north of Cloquet on the east side of the St. Louis River. The occurrence west of Carlton has a level surface, while the portion extending north to Cloquet forms a range of hills along the

valley of the St. Louis River. It is a glacial soil derived from the drift.

The drainage of the Miami gravelly sandy loam is very complete, and in seasons of inadequate rainfall the crops are apt to suffer from drought. The average yield of oats is 35 bushels per acre, while 150 bushels of potatoes is considered a fair crop. Barley and rye are grown to some extent, and vegetables and all truck crops do well.

The following table gives the average results of mechanical analyses of the fine earth of the Miami gravelly sandy loam:

Mechanical analyses of Miami gravelly sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
12927, 13550.....	Soil.....	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
12928, 13551.....	Subsoil.....	6.7	16.4	12.4	13.2	11.9	27.6	11.3
		7.1	24.1	19.4	28.5	6.1	8.5	6.2

BARNUM LOAM.

The soil of the Barnum loam, to a depth of from 8 to 14 inches, consists of a brown loam. The subsoil is a heavy loam, usually lighter in color than the soil, and grades into a stiff brownish-red clay at from 18 to 24 inches. On the top of small knolls this heavy clay comes nearer the surface, and in a few instances the loam covering was found to be but 3 or 4 inches deep. On the surface are a number of stones and boulders, though not in sufficient quantity to interfere with cultivation. A small proportion of gravel is also mixed with the soil.

Only two small areas of this type were mapped. One lies immediately to the south and east of Mahtowa, while the other is found between Mahtowa and Barnum. The surface is rolling, and the natural drainage is generally good, though the lower lying portions of the type could be greatly improved by tile drains.

The Barnum loam is a glacial soil and is closely related to the Barnum stony loam found in the southwest corner of the area in the vicinity of Barnum. The gradation from the loam to the heavy sandy loam is very gradual, and the boundary line between the two was therefore somewhat difficult to locate accurately.

Nearly all of the type is under cultivation. It is especially adapted to dairy farming. Hay yields an average of 2 tons per acre, and 40 bushels of oats is considered a fair crop. Not much wheat is grown at present; the yield is about 25 bushels per acre.

The results of mechanical analyses of the fine earth of the soil and subsoil of this type are given in the following table:

Mechanical analyses of Barnum loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
13560.....	Soil.....	0.8	3.1	7.2	18.2	10.1	42.8	17.3
13561.....	Subsoil....	.7	1.7	3.4	10.9	10.4	45.1	27.8

MIAMI FINE SAND.

The Miami fine sand consists of a fine brown or light-brown sand 10 inches deep, underlain by a sand of the same texture, though lighter in color. Only 2 square miles were mapped. The type is located in the central part of T. 47, R. 17, where the surface material changes from lacustrine deposits to the glacial drift. The occurrence is in the form of low ridges and probably marks the old shore line of an arm of Lake Superior. None of the type is under cultivation, though it is well adapted to the production of early truck crops.

The results of mechanical analyses of a typical sample of the surface soil and subsoil of this type is shown in the following table:

Mechanical analyses of Miami fine sand.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
12929.....	Soil.....	0.3	3.5	9.9	58.6	17.8	5.7	4
12930.....	Subsoil....	.3	2.7	12.9	64.1	16.0	2.4	1

MUCK.

The surface materials of the Muck consist of organic matter in varying stages of decomposition, accumulated to a depth of 8 inches or more, and often mixed with earth from the adjoining slopes or from the underlying beds of clay and sand. The material often extends to a depth of many feet, though clay, gravel, or sand may be encountered anywhere from 8 inches to 3 feet.

The area of Muck which extends from Sand Lake to a point 5 miles east of Barnum is underlain by sand at from 8 to 18 inches. Another extensive area begins 1½ miles north of Barnum and extends northeast for a distance of 6 miles. It varies in width from one-fourth to 1 mile and includes practically all of sec. 29, T. 47, R. 18, from which it has been called "the swamp of 29." In this area the Muck is of great depth. The area of Muck that extends from the intersection of Otter Creek and the Northern Pacific Railroad to Atkinson is underlain, at

least throughout a part of its course, by gravel and in a few instances by closely bedded stones and boulders. This stretch of Muck marks an ancient outlet of Lake Superior, and the organic matter has accumulated over the old stream channel. Within the Fond du Lac Indian Reservation are numerous Muck areas of considerable size.

Throughout the Muck areas are a number of small lake beds filled with decaying vegetable matter which is now only partially decomposed. This material should be classed as Peat, but the extent of such areas is small and it was not practicable to make a separation.

The characteristic growth on the Muck consists of tamarack, white cedar, and black ash, giving rise to the locally well-known terms "tamarack," "cedar," and "black ash" swamps. Where the surface is continually covered with water, which renders conditions unfavorable for the growth above mentioned, there is a dense covering of sphagnum moss.

Over the greater part of the Muck areas decomposition has reached an advanced stage, and such areas when drained should be capable of producing large yields of specially adapted crops. Many of the more swampy areas could be drained by removing the obstructions from the natural waterways. By deepening the stream channels and constructing a few open ditches thousands of acres could be reclaimed, yet it is not probable that any action will be taken in this direction until the country becomes more thickly settled and there is a greater demand for farm land. At the head of Hay Lake a small area of Muck has been cleared and drained, and 2 tons of hay per acre are reported as an average crop. No other crops have as yet been grown upon this type, but oats and corn for fodder would undoubtedly give profitable returns.

ROUGH STONY LAND.

The soil of the Rough stony land is somewhat variable. It consists chiefly of a heavy sandy loam or loam underlain by a heavy sandy loam. The surface is generally rough and broken and so thickly strewn with stones and boulders that it is of little value for agricultural purposes. Small rock outcrops are of frequent occurrence.

Only 8 square miles of this type were mapped. Its most extensive development is in the northeastern part of the area, where it occupies the more gentle slopes and a part of the summits of the hills which overlook the valley of Lake Superior. North of Carlton is a small, low-lying area in which the stones are so thickly bedded that a person can cross by stepping from one stone to another. A similar area occurs near the railroad, 2 miles above Atkinson. Other small patches are found in various parts of the survey.

The Rough stony land may be used to some extent for grazing purposes, but further than this it is of no value for agricultural purposes.

MEADOW.

The type mapped as Meadow occupies the low, flat lands along streams and is subject to overflow in times of high water. The soil, which has been reworked by stream action, consists chiefly of a heavy loam and the subsoil is usually sand or gravel, though it is too variable to be classified with any of the other types mapped. The largest proportion of the type occurs along the Moosehorn River and Otter Creek. A large part of the Meadow is free from tree growth and considerable quantities of wild hay are cut each year. None of the type is under cultivation.

ROCK OUTCROP.

Extending northeast from Short Line Park, along the steep slope from the upland to the valley of Lake Superior, is a series of cliffs, ledges, and other areas too stony to be suited to any agricultural purpose. Similar areas of lesser extent occur between Thomson and Cloquet, and at a few other points along the St. Louis River and Otter Creek. The location of such areas has been indicated on the map by means of color, except where too small to appear on the map, in which case they have been included in the type with which they occur.

AGRICULTURAL CONDITIONS.

The agricultural interests of the area surveyed are still in the early stages of development. While only about 10 per cent of the land is now under cultivation, and while the sum total of the agricultural wealth is comparatively small, enough has been accomplished on the various soils now being tilled to demonstrate their ability to produce profitable crops, and thus make general farming in this region successful.

The greater proportion of the land within the area is now in the hands of real estate companies, which deal with the new settlers and sell to them "by contract." The land is selected and a small sum paid down. A contract is then made by which the purchaser agrees to pay the remainder in a specified number of installments. The companies are usually lenient, and in case of sickness or poor crops, and consequent inability to meet payments, the time is extended. When the last payment is made the purchaser is given a deed to the property.

Those who have been engaged in farming for a number of years are in a fairly prosperous condition. The buildings are substantially constructed and usually in good repair. About 90 per cent of the farms are operated by their owners, and only a small proportion of these have any incumbrance. The average size of farms is 85 acres.

But little difficulty is experienced in securing competent labor for the farm. The wages vary from \$20 to \$26 a month with board. During the winter months the farm hands secure employment in the lumber woods farther north at \$30 a month.

Clearing the land and preparing it for the first crop is a difficult task, the most expensive feature being the removal of the stumps. The value of unimproved land varies from \$5 to \$15 an acre, and the cost of removing the stumps equals and frequently exceeds the original purchase price. The pine stumps decay very slowly, and as fire is not an effective agent in removing them, the stump-puller operated by horse power is in common use. The steam puller is more powerful and will remove stumps of almost any size, but on account of the cost few can afford such an outfit.

Owing to the number of stumps and the irregularity of the surface in the newly cleared fields, the method of cultivation is still crude, and it is necessary to use the scythe and cradle in harvesting hay and grain. In the older communities, however, improved farm machinery is in general use.

Hay has always been the principal crop grown within the area, though wheat, oats, rye, barley, potatoes, and vegetables are well adapted to this region. With the exception of wheat, the acreage of these products is increasing each year. A large proportion of the area is well adapted to the production of clover and timothy, and throughout the "cut-over lands," along the old lumber roads and about the old camps, and wherever seed have been scattered by stock, there is a luxuriant growth of these plants. The wild grasses also thrive, and yields of 2 or 3 tons of hay per acre are not uncommon. Clover and timothy are sown in the spring with oats as a nurse crop. The wild grasses are plentiful, and on the Meadow land along many of the streams where there is no underbrush a large quantity of hay is cut and cured each year. Throughout the Nemadji plains there is an abundance of excellent pasture during the entire summer, and if the brush were removed, good yields of hay could be secured.

But little wheat is grown within the area, though in the southwestern part yields of 25 bushels per acre are reported. The bluestem wheats seem to be less affected by rust than the other varieties and also produce larger yields. Wheat should not be sown on newly cleared land until two or three other crops have been grown and the soil becomes mellow. As a whole the area is not adapted to the extensive production of wheat, and the growing of this staple should be limited at most to a supply for home consumption. When the cleared area is small, and especially when stumps prevent the use of modern harvesting machinery, it is impossible to compete with the prairie sections in the growing of wheat.

On account of the extensive lumbering industry carried on in the northern part of the State there is a good demand for oats, and this demand will continue as long as the pine forests remain. Oats will do better on the newly cleared land than any other crop, and under favorable conditions a good yield may always be expected. The

Miami stony loam is well adapted to this crop, and the Miami sandy loam also produces fair yields. A few fields were seen on the Superior clay, and here the grain stood thick upon the ground and was making a vigorous growth. The Improved Ligowa and the "Minnesota No. 35" are two varieties which have been grown to some extent and seem to be better adapted to the soil and climate than other varieties. A loss of weight and a decrease in the yield sometimes occur when new varieties are first tried. Those which maintain their good qualities should be selected and an effort made to assist them in becoming adapted to this particular region. The oat crop is sown between May 5 and 20 and is harvested the latter part of August. It is sometimes possible to sow earlier than this, and when conditions are favorable this is advisable. The early sown grain has the advantage over that sown later in that it forms a better root system, is better able to resist drought later on, ripens earlier, and usually produces larger yields.

A small amount of barley is grown and is used mostly in feeding hogs. Potatoes and the various root crops yield very well on the light soils of the area. Truck farming should shortly develop into a profitable industry. Strawberries do especially well, and as they ripen after the southern supply is exhausted a good price can always be secured.

The conditions within the area are generally considered to be unfavorable for the production of corn. The growing season is comparatively short and the nights are usually cool. Although only a small amount of corn has been grown within the area, it has been demonstrated that by careful selection hardier and earlier maturing varieties can be developed. The smaller and hardier of the flint varieties are now being grown at Grand Rapids, Minn., which is still farther north, and it is believed that the same success may be attained in this region. Sweet corn matures within the area, and a small amount of field corn has been grown for fodder.

In order to maintain the productiveness of the soils, careful management will be necessary. No commercial fertilizers are used. The barnyard manure made during the winter is spread over the fields in the spring, but the supply is insufficient to cover the cultivated fields more than once in about five years. Oats and potatoes usually constitute the first crop grown on newly cleared land. Oats may be followed by grass, clover, and timothy sown with the grain in the spring. Wheat may follow the oats, though in no part of the area is there a fixed rotation of crops practiced. Sections most convenient and most easily cleared are usually selected without special note being taken of the character of the soil or its adaptation to crops to be grown.

Dairy farming gives promise of becoming an important industry. The wild grasses, together with the clover and timothy which grow luxuriantly over the greater proportion of the area, afford excellent pasture throughout the summer and fall. While it is necessary to shelter and feed the cattle for about five months during the winter, an abundant supply of hay can be easily secured, and this, with a small amount of ground feed, will carry the stock through the winter in good condition. The growing of corn for fodder and ensilage will reduce the cost of feed and greatly assist in increasing the milk supply. The building of silos is to be recommended.

A small creamery is in operation at Mahtowa and another at Barnum, just outside of the area. These are operated by private companies. The cream is purchased from the farmer, the price paid varying with the butter-fat content. Tests run from 3.5 to 6.5 per cent, with an average for the season of 1904 of 4.5 per cent. A small amount of milk is brought into the towns from the surrounding country district, but the supply is in no case equal to the demand.

The transportation facilities of the area are adequate to the demands of a thickly settled and highly prosperous community. The Northern Pacific Railroad and the Great Northern Railway systems traverse the area and cross at Carlton. The Duluth and St. Paul Short Line passes through and connects Duluth and Superior with St. Paul and Minneapolis, as does also a branch of the Great Northern Railroad. Duluth and Superior, together with the numerous lumbering and mining towns in northeastern Minnesota, afford a ready market for large amounts of farm produce. But a small proportion of this demand is supplied by the products of the area surveyed.

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SOIL MAP

MINNESOTA-WISCONSIN
CARLTON SHEET

SOIL
PROFILE
(3 feet deep)

Miami stony loam
Sgt

Miami gravelly sandy loam
Sgg

Miami sand
S

Miami fine sand
Sf

Miami sandy loam
Ssc

Superior silt loam
Sic

Superior clay
C

Barnum stony loam
Scgt

Barnum loam
Sc

Silt loam
Sgt
Sandy loam and gravel
Sgt
Sand
Fine sand
Sandy loam
Stony loam
Loam
Clay

LEGEND

Msl
Miami stony loam

Mg
Miami gravelly sandy loam

Ms
Miami sand

Mfs
Miami fine sand

Mi
Miami sandy loam

Si
Superior silt loam

Sc
Superior clay

Bs
Barnum stony loam

Bl
Barnum loam

Rs
Rough stonyland

Mu
Muck

M
Meadow

R
Rock outcrop

